

AP0017

3782-1240



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OCT 03 2001  
Technology Center 2100

UNITED STATES PATENT APPLICATION

OF

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FOR

PROCESSING OF DOCUMENTS



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OCT 03 2001  
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#### Technical Field

The invention relates to methods and devices intended for editing electronically stored documents.

#### Background of the Invention

US Patent Specification US-5,897,648 describes a device and a method for editing electronic documents. An original document is scanned into a computer where an electronic version of the document is stored. The original is then placed on an X/Y digitizing tablet and the position of the document on the digitizing tablet is correlated with the scanned version of the document. Editing is then carried out on the digitizing tablet with the aid of a digitizing pen coupled to the tablet. The editing is done in the form of markings on the original, the positions of the markings being transferred via the tablet to the computer. The editing markings are interpreted and converted into electronic form in the computer, after which the edited electronic document is displayed.

The use of an invention according to US-5,897,648 has the very significant disadvantage that a user is forced to be located at the computer or at least at the digitizing tablet when editing.

A general problem is thus how to provide for simple and flexible editing of electronic documents.

#### Summary of the Invention

It is an object of the invention to address problems associated with the prior art. This object aim is

achieved by a method and a computer program according to claim 1 below and a system according to claim 5.

In its most general form, the invention is characterized in that, on the basis of an electronically stored document, which can be of any type such as text, image, drawing etc., the document is printed on a surface, preferably a sheet of paper, which is provided with a position-coding pattern. Manual editing is then carried out on the printout surface with a device which comprises means for reading the position-coding pattern and also a pen point for marking on the surface. Editing is done by means of a code which is in the form of symbols from a predetermined set of symbols, on the sheet of paper. Transferring of the editing information, i.e. the symbols applied to the surface, is done to a storage and processing device, preferably a computer. This transfer can be done directly during the editing or on a later occasion. Interpretation of the editing code is then done, wholly or partially in the computer, in interaction with the document stored in the computer, whereafter changes are made to the stored document in direct dependence on the interpretation.

A number of advantages of the invention, which are associated with simplicity of processing, are obvious: it is simple and easy to understand, i.e. it is a question of intuitive processing of documents of the traditional type, i.e. paper printouts. This also results in a low

learning threshold for the persons who are to carry out the editing.

Furthermore, it is an advantage that it is simple to edit documents without the person editing needing to be located at a computer where the document is stored, or to be tied to a complicated input device which in the prior art is exemplified by a digitizing tablet. The editing information can thus be advantageously stored in the input device for subsequent transfer to the computer/storage location.

It is also advantageous to directly obtain a copy of the editing in the form of the manually edited print-out as offered by the invention.

#### Brief Description of the Drawings

Fig. 1 schematically shows an embodiment of a product which is provided with a position-coded pattern.

Figs 2a-2d schematically show how the symbols can be configured in an embodiment of the invention.

Fig. 3 schematically shows an example of 4x4 symbols which are used for coding a position.

Fig. 4 schematically shows a device according to the present invention which can be used for position-determination in three dimensions.

Fig. 5a shows a printout of a text document with manually drawn editing instructions.

Fig. 5b shows a printout of a drawing document with a manually drawn editing instruction.

### Preferred Embodiments

For the sake of clarity, the detailed description of the invention below has been divided into a number of part-descriptions. As an introduction, a coding pattern will be presented with reference to Figs 1, 2a-d and 3. This coding pattern represents position information which can be used in a method according to the invention. After presentation of the coding pattern, a device which is intended to be used in manual editing of a printed document is presented in connection with Fig. 4. The device, which is pen-shaped, reads the position-coding pattern and where applicable also text and is provided with a pen point to make editing markings on the printed document visible. After that is shown, with reference to Figs 5a and 5b, how examples of manual editing information are drawn on a printout of a text document (Fig. 5a) and a document (Fig. 5b) which contains a drawing figure.

Fig. 1 shows a part of a product in the form of a sheet of paper 1 which is provided on its surface 2 with an optically readable position-coding pattern 3 enabling position-determination to be carried out. The position-coding pattern consists of symbols 4 which are systematically arranged over the surface 2 so that it has a "patterned" appearance. The sheet of paper has an x coordinate axis and a y coordinate axis. In this case, position determination can be carried out on the entire surface of the product. In other cases, the surface which

allows position determination may consist of a smaller part of the product. For example, the sheet of paper can be used for producing an electronic representation of information which is written or drawn on the surface. The electronic representation can be produced by continuously determining the position of the pen on the sheet of paper by reading the position-coding pattern while writing on the surface with a pen.

The position-coding pattern comprises a virtual raster which is thus neither apparent to the human eye nor can it be detected directly by a device which is to determine positions on the surface, and a plurality of symbols 4 each of which can assume one of four values "1"- "4" as described in the text which follows. In this connection, it should be pointed out that the position-coding pattern in Fig. 1 has been greatly enlarged for the sake of clarity. Moreover, it is only shown on a part of the sheet of paper.

The position-coding pattern is arranged in such a manner that the position of a partial surface on the writing surface is coded by the symbols on this partial surface. A first and a second partial surface 5a, 5b are shown by dashed lines in Fig. 1. The part of the position-coding pattern (in this case 3 x 3 symbols), which is located on the first partial surface 5a, codes a first position, and the part of the position-coding pattern which is located on the second partial surface 5b codes

a second position. The position-coding pattern is thus partly common to the adjoining first and second positions. Such a position-coding pattern is designated as "floating" in this application.

Figs 2a-d show an embodiment of a symbol which can be used in the position-coding pattern according to the invention. The symbol comprises a virtual raster point 6 which is represented by the intersection between the raster lines, and a marking 7 which has the form of a dot. The value of the symbol depends on where the marking is placed. In the example in Fig. 2, there are four possible placements, one on each one of the raster lines which extend from the raster points. The displacement from the raster point is equal for all values. In the text which follows, the symbol has the value 1 in Fig. 2a, the value 2 in Fig. 2b, the value 3 in Fig. 2c and the value 4 in Fig. 2d. In other words, there are four different types of symbols.

Each symbol can thus represent four values "1-4". This means that the position-coding pattern can be divided into a first position code for the x coordinate and a second position code for the y coordinate. The dividing is done as follows:

Symbol value	x code	y code
1	1	1
2	0	1
3	1	0
4	0	0

The value of each symbol is thus translated into a first digit, in this case bit, for the x code and a second digit, in this case bit, for the y code. In this manner, two completely independent bit patterns are obtained. The patterns can be combined into a common pattern which is coded graphically with the aid of a plurality of symbols according to Fig. 2.

Each position is coded with the aid of a plurality of symbols. In this example, 4x4 symbols are used for coding a position in two dimensions, i.e. an x coordinate and a y coordinate.

The position code is built up with the aid of a number series of ones and zeros which has the characteristic that no sequence of four bits occurs more than once in the series. The number series is cyclic, which means that the characteristic also applies when the end of the series is coupled together with its beginning. A sequence of four bits thus always has an unambiguously determined position in the number series.

The series can have a maximum length of 16 bits if it is to have the characteristic described above for



sequences of four bits. In this example, however, only a seven-bit-long series is used as follows:

" 0 0 0 1 0 1 0"

This series contains seven unique sequences of four bits which code a position in the series as follows:

Position in the series	Sequence
0	0001
1	0010
2	0101
3	1010
4	0100
5	1000
6	0000

For coding the x coordinate, the number series is written sequentially in columns over the entire surface which is to be coded. The coding is based on the difference or position displacement between numbers in adjoining columns. The magnitude of the difference is determined by the position in the number series at which one allows the column to begin (i.e. with which sequence). More specifically, taking the difference modulo seven between, on the one hand, a number which is coded by a four-bit sequence in a first column and which thus can have the value (position) 0-6, and, on the other hand, a corresponding number (i.e. the sequence at the same "level") in an adjoining column, the result will be the

same independently of where along the two columns the comparison is made. It is thus possible to code an x coordinate which is constant for all y coordinates with the aid of the difference between two columns.

Since each position on the surface is coded with 4x4 symbols in this example, three differences (having the value 0-6) according to the above are available for coding the x coordinate. The coding is then carried out in such a manner that the three differences will always have the value 1 or 2 and the other two will have values within the range of 3-6. Thus, no differences may be zero in the x code. In other words, the x code is structured in such a manner that the differences will be as follows: (3-6) (3-6) (1-2) (3-6) (3-6) (1-2) (3-6) (3-6) (1-2)...

Each x coordinate is thus coded with two numbers between 3 and 6 and a subsequent number which is 1 or 2. Subtracting three from the high numbers and one from the low one provides a number in mixed base which directly yields a position in the x direction from which the x coordinate can then be determined directly as shown in the example below.

Using the principle described above, x coordinates 0,1,2... can thus be coded with the aid of numbers which represent three differences. These differences are coded with a bit pattern which is based on the number series above. Finally, the bit pattern can be coded graphically with the aid of the symbols in Fig. 2.

In many cases, it will not be possible to obtain a complete number which codes the x coordinate, but parts of two numbers, when reading 4x4 symbols. Since the least significant part of the number is always 1 or 2, however, a complete number can be simply reconstructed.

The y coordinates are coded according to the same principle as used for the x coordinates. The cyclic number series is written repeatedly in horizontal rows over the surface which is to be position-coded. Exactly as in the case of the x coordinates, the rows are allowed to begin at different positions, i.e. with different sequences, in the number series. However, for the y coordinates, it is not differences which are used but the coordinates are coded with numbers which are based on the starting position of the number series in each row. Once the x coordinate for 4x4 symbols has been determined, it is possible to determine the starting positions in the number series for the rows which are included in the y code in the 4x4 symbols. In the y code, the most significant digit is determined by allowing it to be the only one which has a value in a specific range. In this example, a row of four is allowed to begin at position 0-1 in the number series to indicate that this row relates to the least significant digit in a y coordinate, and the other three begin at position 2-6. In the y direction, a number series according to the following is thus found:  
(2-6) (2-6) 2-6) (0-1) (2-6) (2-6) (2-6) (0-1) (2-6)...

Each y coordinate is thus coded with three numbers between 2 and 6 and a subsequent number between 0 and 1.

Subtracting 1 from the low number and 2 from the high ones provides, in a corresponding manner as for the x direction, a position in the y direction in mixed base from which the y coordinate can be determined directly.

Using the method above,  $4 \times 4 \times 2 = 32$  positions can be coded in the x direction. Each such position corresponds to three differences, providing  $3 \times 32 = 96$  positions. Furthermore, it is possible to code  $5 \times 5 \times 5 \times 2 = 250$  positions in the y direction. Each such position corresponds to 4 rows, providing  $4 \times 250 = 1000$  positions. Altogether, it is thus possible to code  $96,000$  positions. Since the x coding is based on differences, however, it is possible to select the position at which the first number series begins. Taking into account that this first number series can begin at seven different positions, it is possible to code  $7 \times 96,000 = 672,000$  positions. The starting position for the first number series in the first column can be calculated once the x coordinate has been determined. The above-mentioned seven different starting positions for the first series can code different sheets or writing surfaces on a product.

To further illustrate the invention according to this embodiment, a specific example follows which is based on the embodiment of the position code described.

Fig. 3 shows an example of an image with 4x4 symbols which are read by a device for position determination.

These 4x4 symbols have the following values:

4 4 4 2

3 2 3 4

4 4 2 4

1 3 2 4

These values represent the following binary x code and y code:

<u>x-code</u>	<u>y-code</u>
0 0 0 0	0 0 0 1
1 0 1 0	0 1 0 0
0 0 0 0	0 0 1 0
1 1 0 0	1 0 1 0

The vertical x sequences code the following positions in the number series: 2 0 4 6. The differences between the columns will be -2 4 2, which modulo 7 gives: 5 4 2 which, in mixed base, codes position  $(5-3) \times 8 + (4-3) \times 2 + (2-1) = 16 + 2 + 1 = 19$ . Since the first coded x position is position 0, the difference which lies within the range 1-2 and which appears in the 4x4 symbols is the twentieth such difference. Since there are also a total of three columns for such difference and there is one start column, the vertical sequence farthest to the right in the 4x4 x code belongs to the 61st column in the x code ( $3 \times 20 + 1 = 61$ ) and the one farthest to the left belongs to the 58th.

The horizontal y series codes the positions 0 4 1 3 in the number series. Since these series begin in the 58th column, the starting position of the rows is these numbers minus 57 modulo 7, which provides the starting positions 6 3 0 2. Translated into digits in mixed base, this becomes 6-2, 3-2, 0-0, 2-2 = 4 1 0 0, the third digit being the least significant digit in the number in question. The fourth digit is then the most significant digit in the next number. In this case, it must be the same as in the number in question. (The exception is when the number in question consists of the highest possible digits in all positions. It is then evident that the beginning of the next number is one greater than the beginning of the number in question.)

In mixed base, the position of the four-digit number will be  $0 \times 50 + 4 \times 10 + 1 \times 2 + 0 \times 1 = 42$ .

The third row in the y code is thus the 43rd which has the starting position 0 or 1, and since there are a total of four rows on each such row, the third row is number  $43 \times 4 = 172$ .

Thus, the position of the topmost left corner for the 4x4 symbol group is (58,170) in this example.

Since the x sequences in the 4x4 group begin on row 170, the x columns of the entire pattern begin at positions  $((2\ 0\ 4\ 6) - 169) \text{ modulo } 7 = 1\ 6\ 3\ 5$  in the number series. Between the last starting positions (5) and the first starting positions, numbers 0-19 are coded in mixed

base, and by adding up the representations of the numbers 0-19 in mixed base, the total difference between these columns is obtained. A primitive algorithm for doing this is to generate these twenty numbers and directly add up their digits. The sum obtained is called  $s$ . The sheet or writing surface is then given by  $(5-s)$  modulo 7.

In the example above, an embodiment has been described where each position is coded with  $4 \times 4$  symbols and a number series with 7 bits is used. Naturally, this is only one example. Positions can be coded with more or fewer symbols. The number of symbols need not be the same in both directions. The number series can be of different length and does not need to be binary but may be based on another base. Different number series can be used for coding in the  $x$  direction and coding in the  $y$  direction. The symbols can have different numbers of values.

In the example above, furthermore, the marking is a dot. Naturally, it may have a different appearance. For example, it may consist of a line which begins at the virtual raster point and extends therefrom to a predetermined position.

In the example above, the symbols are used within a square partial surface for coding a position. The partial surface can have a different shape, for example hexagonal. The symbols do not need to be arranged in rows and columns at an angle of 90 degrees to each other either,

but can also be arranged in some other manner.

For the position codes to be detected, the virtual raster must be determined. This can be done by studying the distance between different markings. The shortest distance between two markings must originate from two adjoining symbols with the value 1 and 3 so that the markings are lying on the same raster line between two raster points. When such a pair of markings has been detected, the associated raster points can be determined with knowledge of the distance between the raster points and the displacement of the markings from the raster points. Once two raster points have been located, additional raster points can be determined with the aid of measured distances to other markings and with knowledge of the relative distance of the raster points.

An embodiment of a device for position determination, whose spatial relationship to a surface can be determined, is shown schematically in Fig. 4. It comprises a casing 11, which is approximately shaped like a pen. In the short end of the casing, there is an opening 12. The short end is provided to bear against or to be held at a short distance from a surface S on which the position determination is to occur. In the figure, a normal direction  $\bar{v}_z$  to the surface S and an axis A extending through the device are indicated. Axis A forms an angle of inclination  $\theta$  with the normal direction  $\bar{v}_z$ .

The casing mainly contains an optical part, an elec-



tronic part and a power supply.

The optical part comprises at least one light-emitting diode 13 for illuminating the surface which is to be imaged, and a light-sensitive area sensor 14, for example a CCD or CMOS sensor, for registering a two-dimensional image. The device may also comprise a lens system.

The power supply for the device is obtained from a battery 15 which is mounted in a separate compartment in the casing.

The electronic part contains image-processing means 16 for determining a position on the basis of the image registered by means of the sensor 14 and more specifically a processor unit with a processor which is programmed to read images from the sensor and to perform position determination on the basis of these images.

In this embodiment also, the device comprises a pen point 17, with the aid of which it is possible to write normal pigment-based writing on the surface on which the position determination is to occur. The pen point 17 can be retracted and extended so that the user can control whether or not it is to be used. In certain applications, the device does not need to have a pen point at all.

The device also comprises buttons 18, with the aid of which the device is activated and controlled. It also has a transceiver 19 for wireless transmission, e.g. by means of IR light or radio waves, of information to and from the device. The device can also comprise a display

20 for showing positions or registered information.

Applicant's Swedish Patent No. 9604008-4 describes a device for registering text. This device can be used for position determination if it is programmed in a suitable manner. If it is to be used for pigment-based writing, it must also have a pen point.

The device can be divided into different physical casings, a first casing containing components which are necessary for obtaining images of the position-coding pattern and for transferring these to components which are located in a second casing and which carry out the position determination on the basis of the image or images registered.

As mentioned, the position determination is done by a processor which thus must have software for locating and decoding the symbols in an image and for determining positions from the codes thus obtained. A person skilled in the art can design software on the basis of the above example, which carries out position determination on the basis of an image of a part of a position-coding pattern.

Furthermore, the person skilled in the art can design software on the basis of the above description, for printing the position-coding pattern.

In the embodiment above, the pattern is optically readable and the sensor thus is an optical sensor. As mentioned, the pattern can be based on another parameter than an optical parameter. Naturally, in that case, the

sensor must be of a type which can read the parameter in question.

In the embodiment above, the raster is a grid network. It can also have other forms.

In the embodiment above, it is not the longest possible cyclic number series which is used. This provides a certain redundancy which can be used, for example, for checking the turning of the read group of symbols.

Fig. 5a shows a printout 501 of a text document which is preferably stored in a computer. The printout 501 is suitably done on a sheet of paper, the surface of which is provided with a position-coding pattern as described above in connection with Figs 1-3. For the sake of clarity, however, no such pattern is shown in Fig. 5a.

Editing markings are schematically exemplified in Fig. 5a at reference numerals 502, 503 and 504. A misspelt word "two", the wrong letter "w" of which has been provided with a line and has been marked in the right-hand margin that it is to be replaced by the letter "o" 502. An incorrect word "green" has been provided with a line and marked in the right-hand margin that it is to be replaced by the word "gold" 503. The words "fade" and "not" have been marked 504 with a symbol which, on interpretation, is to indicate that the words are to change places with one another.

Fig. 5b very schematically shows a drawing consisting of simple geometric figures. A cross marking 505 has

been drawn on one side of a rectangle in order to indicate that the side is to be erased.

The symbols and markings shown in Figs 5a and 5b should only be seen as examples of how editing markings can be configured. The symbols can be a subset of a larger set of editing markings comprising more or less complicated indications of how the subsequent interpretation should be carried out and how the real changes of the stored document are to appear. The set of editing commands can be determined in advance or be generated by, for example, a user through a suitable learning process according to the prior art technique.

Transferring editing information from the reading device comprises the transfer of position data which are read by the reading device. This transfer can be done at the same time as the user is writing the editing symbols on the printed document, or at a later time.